5 Assessing Performance

5.1 Purpose

The analysis of the existing transportation system uses the data collected and developed as described in previous chapters to evaluate the transportation system prior to making any changes to land use or infrastructure. This chapter presents analysis procedures not specific to traffic flow type and identifies specific methodologies and input parameters to be used on ODOT projects. Topics covered include:

- Crash Analysis
- Peak Hour Factors
- Access Management
- Sight Distance
- Multi-Modal Analysis
- Other Analysis Issues/Procedures

5.2 Crash Analysis

Crash analysis typically involves the identification of the problem areas on facilities experiencing an above-average frequency of crashes or reoccurring crash patterns and an investigation of conditions that may contribute to the problem identified. If an analyst generally understands crash trends within a study, the analyst can use the information in the analysis and recommendations. This analysis should not be confused with the operational analysis that would be done separately by Region Traffic staff.

5.2.1 Calculating Crash Rates

Crash rates are commonly used to determine if the frequency of crashes experienced at a given intersection or segment of roadway is above average. Because the total number of crashes experienced on a segment or intersection of roadway(s) is typically proportional to the number of vehicles using that facility, rates are often calculated to allow for comparisons of different facilities. The most common basis for comparison is to calculate the number of crashes experienced per million users. Specifically, for roadway segments, the number of crashes per million vehicle miles of travel (MVM) is calculated and for intersections, the number of crashes per million entering vehicles (MEV). These rates can also be calculated using only specific crash types such as fatalities, fatal, injury or property damage only crashes. The corresponding formulas for these calculations are shown in Table 5-1.

Table 5-1 Equations for Crash Rate Calculations

Description	Expression	Formula
Segment Crash Rate (crashes per million vehicle miles of travel, MVM)	Annual number of crashes times one million, divided by the annual vehicle-miles of travel.	$\frac{\text{Annual number of crashes} \times 10^6}{(\text{AADT}) \times (365 \text{ days/year}) \times (\text{segment length in miles})}$
Intersection Crash Rate (crashes per million entering vehicles, MEV)	Annual number of crashes times one million, divided by the annual volume of entering traffic.	$\frac{\text{Annual number of crashes} \times 10^6}{(\text{AADT}) \times (365 \text{ days/year})}$

Note that care should be taken when calculating crash rates for segments that are less than one mile. The resulting rate for a short section can appear to be much higher than is actually the case. Evaluate crash rates for short sections by trying small changes in the number of crashes. If the changes in crash rate are dramatic then either this type of crash rate should not be used or its use should be accompanied with a warning. Whenever possible crash rates for short sections should be normalized (or lengthen the section) to a full one-mile section without including features that will significantly influence the outcome, e.g., a major intersection hosting a high concentration of crashes.

For reporting crash rates on state highways, ODOT uses the segment crash rate. ODOT does not have an established standard intersection crash rate to compare with as a baseline. The ODOT CAR Unit publishes an annual document called the *Oregon State Highway Crash Rate Tables*, available at: http://www.oregon.gov/ODOT/TD/TDATA/car/CAR_Publications.shtml. In this document crash rates for given segments of all state highways are calculated and listed for each of the last five years. In addition to this a variety of summaries of crash rates for state highways considering fatalities and different highway types, as well as information about the data used in the crash rate calculations, is provided.

Of particular interest is Table II, which shows statewide average crash rates for each of the last five years, for freeways and non-freeways on the state highway system, by urban and rural area and by primary and secondary designation. This table is often used in crash analysis to compare the segment crash rate calculated for a study highway to the statewide average rate shown in the table for a comparable highway type. In the selection of the appropriate highway type for comparison, the analyst must determine whether the study highway segment is classified as a freeway or non-freeway, is located within an urban or rural area and is on the primary or secondary highway system (a listing of primary and secondary highways is included after Table IV). Note that the category “State Highway System” provided alongside the primary and secondary system categories in Table II is merely a combination of the primary and secondary highway systems and should not be used for most crash rate comparisons.

Example 5-1 Crash Rate Calculation and Comparison

A principal highway segment in a rural area has experienced 22 reported crashes over the last 3 years. The segment ADT is 23,000 and length is 1.6 miles.

$$\text{Rate} = \frac{\text{Number of Crashes X 1,000,000}}{\text{Length (in miles) X ADT X (Yrs X 365)}}$$

$$= \frac{\text{22 X 1,000,000}}{\text{1.6 X 23,000 X 3Yrs X 365}}$$

= 0.55 Crashes per Million Vehicle Miles (MVM)

As shown in Figure 5-1, the statewide average crash rates are as follows:

2005	0.67
2006	0.69
2007	0.68
Average	0.68

The segment crash rate of 0.55 is less than the average statewide rate of 0.68.

Figure 5-1 Statewide Crash Rate Table

TABLE II: FIVE-YEAR COMPARISON OF STATE HIGHWAY CRASH RATES

Table II presents a comparison of state highway crash rates for the past five years, for urban and rural areas, by functional classification. Mileage is shown for the current data year only.

See Table IV for information on official highway mileage and VMT data.

JURISDICTION AND FUNCTIONAL CLASSIFICATION	MILES*	2007 Rate	2006 Rate	2005 Rate	2004 Rate	2003 Rate
TOTAL STATE HWY SYSTEM						
Interstate Freeways						
Other Fwys/Expressways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Urban Collectors						
Rural Major Collectors						
Rural Minor Collectors						
Rural Local						
URBAN HWY SYSTEM						
Interstate Freeways						
Other Fwys/Expressways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Urban Collectors						
Urban Cities						
Interstate Freeways						
Other Fwys/Expressways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Urban Collectors						
Suburban Areas						
Interstate Freeways						
Other Fwys/Expressways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Urban Collectors						
RURAL HWY SYSTEM						
Interstate Freeways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Rural Major Collectors						
Rural Minor Collectors						
Rural Local						
Rural Cities						
Interstate Freeways						
Non-Freeways (combined)						
Other Principal Arterials						
Minor Arterials						
Rural Major Collectors						
Rural Minor Collectors						
Rural Areas						
Interstate Freeways						
Non-Freeways (combined)						
Other Principal Arterials	2,658.39	0.68	0.69	0.67	0.61	0.71
Minor Arterials						
Rural Major Collectors						
Rural Minor Collectors						
Rural Local						

* Couplet and Roadway 3 data are included. Frontage road and connection data are excluded.

When comparing a statewide average rate to a segment crash rate for a study highway, simply exceeding the statewide average rate should not be interpreted as proof that a section is hazardous. A segment crash rate that exceeds the statewide average crash rate should merely be considered as an indication that further investigation is necessary. It should also be stated that cost effective improvements to increase safety could still be identified even with a segment crash rate lower than the statewide average.

When an intersection crash rate may be appropriate to report, a rule of thumb is that intersections with a crash rate of 1.0 or greater is generally considered to be an indication that further investigation is warranted. . This is not to say whether a location is “bad” if over or “okay” if under 1.0. It should also be stated that cost effective improvements to increase safety could still be identified even with an intersection crash rate lower than the statewide average.

Another analysis tool that ODOT uses is the Safety Priority Index System (SPIS) which provides an alternative method of ranking for intersections and segments of roadways on State Highways. SPIS incorporates crash rate, frequency and severity components to provide a single index to compare a roadway or intersection.

The top 5% SPIS ranking requires the Region Traffic offices to conduct a safety investigation each year to determine if there is an appropriate safety improvement fix to the problem. The SPIS ranking can be determined by contacting the appropriate Region Traffic Office for assistance or at the following intranet website http://intranet.odot.state.or.us/tstrafmgt/PSMS/SPIS/spis.htm The Traffic-Roadway Section is contracting with Oregon State University and Portland State University to develop a Safety Investigations Manual which is planned to be available in Fall of 2009.

5.2.2 Identifying Crash Patterns

The commonly used procedure to identify crash patterns is categorizing crashes by characteristics such as types, time of day, weather conditions and locations. In this form it may be easier for the analyst to identify crash trends such as a high number of a certain type of crash or a location or movement that experiences a disproportionate amount of the total crashes.

Caution should be exercised when identifying actual crash locations from reported data. Crashes may be reported at the nearest integer milepoint even if they occurred hundreds of feet away, i.e., a crash reported at milepoint 12 even though it actually occurred at milepoint 12.34. This can be evidenced by clusters of crashes reported at even milepoints. Crash data should be checked for discrepancies such as where a crash occurred on a curve, but the reported milepoint is located on a straightaway section.

5.2.3 What Data to Report

An analysis report should contain summarized information about crashes within the study area. The summary should contain trends, crash rates and a general discussion of the crashes. If on the state highway the report should contain the segment crash rate and reference to the most recent SPIS data.

5.2.4 Countermeasure Selection

While crash patterns found should be addressed during the alternatives analysis, countermeasure selection is generally not addressed in most transportation analysis projects, but is conducted as a separate effort that may be initiated by the identification of crash patterns in the project report. However, the following discussion will help provide an understanding of the potential uses of crash analysis. Countermeasures can generally be grouped into three categories: education, enforcement and engineering.

- Education related countermeasures include a variety of public information campaigns using a broad range of media to reach a target audience. These types of countermeasures can be effective in reducing driver error by making motorists aware of the risks and consequences of certain driving behaviors and environments encountered.
- Enforcement countermeasures typically involve increased policing activity to encourage compliance with existing traffic controls and regulations. Increased enforcement is often implemented when engineering countermeasures are already present, but have become ineffective due to frequent violations by motorists. The application of enforcement countermeasures is typically carried out by the Region Traffic Section.
- Engineering countermeasures include a broad range of improvements or modifications to the transportation system in an attempt to improve roadway safety. Such countermeasures may include geometric improvements, ITS applications, changes to traffic controls (signing, striping, signals, etc.), changes to roadway surfacing, or operational enhancements.

There are many resources that provide potential countermeasures to select from for a given crash pattern. When selecting countermeasures, the analyst should coordinate with the ODOT TEOS.

5.3 Peak Hour Factors

Peak hour factors (PHF) are used to account for the non-uniformity of traffic flow within the peak hour by converting hourly volumes to peak flow rates associated with a selected interval of time within the peak hour. The most common interval of time selected for traffic analysis is the peak 15 minutes. In areas near capacity the peak 15-minute flow can cause up to several hours of congestion. This typically happens when the demand exceeds the available capacity of the transportation system resulting in "peak hour spreading", which is the extension of the peak period caused by a system breakdown. Therefore, it is often essential that the transportation system be designed to accommodate the peak 15 minutes of the peak hour.

Peak hour factors should be applied in most capacity analyses in accordance with the *HCM*, which selected 15-minute flow rates as the basis for most of its procedures. It is especially critical to examine the peak 15-minute period when potential queue lengths may become an issue, and at locations with sharp peaking characteristics such as employment sites and locations with low peak hour factors (less than 0.90).

5.3.1 Calculation

The PHF is typically calculated using data from traffic counts. It is the traffic volume during the peak 60-minute period divided by four times the volume during the peak 15-minute period.

$$\text{PHF} = \frac{\text{Volume During Peak 60-Minute Period}}{4 \times (\text{Volume During Peak 15-Minute Period})}$$

5.3.2 Existing Conditions

PHFs calculated from actual traffic count data should always be used for analysis of existing conditions. In situations where traffic counts are not available in 15-minute intervals (planning-level analysis) the *HCM* suggests the following approximations:

- 0.95 for congested conditions
- 0.92 for urban areas
- 0.88 for rural areas

Where traffic count data has been obtained, one of the three methods for calculation and application of PHFs described below should be followed.

- ***Existing PHF – Method 1:*** The preferred analysis method in most cases uses an intersection PHF to estimate peak 15-minute period equivalent

- ***Step 1:*** Determine the peak 15-minute period that has the highest intersection total entering volume (TEV).
- ***Step 2:*** Calculate the intersection PHF based on the time period determined in Step 1, by dividing the TEV peak 60-minute volume by four times the TEV occurring during the peak 15 minutes.
- ***Step 3:*** In the analysis, apply the intersection PHF from Step 2 to each movement peak 60-minute volume.

- ***Existing PHF - Method 2:*** As an option, in cases where unusual peaking occurs on individual approaches, approach PHFs can be determined from the traffic count volumes. The peak 15-minute period with the highest intersection TEV should be used to determine the PHFs. PHFs are calculated for each approach as follows. If an approach PHF is calculated to exceed 1, entering a value of 1.00 will ensure a slightly conservative analysis.

  - ***Step 1:*** Determine the peak 15-minute period that has the highest intersection total entering volume (TEV).
  - ***Step 2:*** Calculate the PHF for each approach based on the time period determined in Step 1 by dividing the approach peak 60-minute volume by four times the approach peak 15-minute volume.
  - ***Step 3:*** In the analysis, apply the approach PHFs from Step 2 to the approach peak 60-minute volumes (usually calculated by the analysis software).

- ***Existing PHF - Method 3:*** As an additional option in cases where unusual peaking occurs on individual approaches, the traffic count volumes for all movements that occur during the single peak 15-minute period can be used directly in software that multiplies the peak 15-minute period volumes by a factor of four. If this method is used both the actual 60-minute period hourly volumes and the equivalent peak 15-minute hourly flow rates should be shown on the Existing Traffic flow diagrams, and clearly labeled to avoid confusion.

  - ***Step 1:*** Determine the peak 15-minute period that has the highest intersection total entering volume (TEV).
  - ***Step 2:*** For the time period determined in Step 1, enter the peak 15-minute volumes directly in the software.
  - ***Step 3:*** Select software analysis procedure based on the peak 15-minute period.

- *Step 4:* On the flow diagrams show and clearly label both the actual 60-minute period hourly volumes and the equivalent peak 15-minute hourly flow rates to avoid confusion.

5.3.3 Future Conditions

Because traffic flow patterns may change over time and future conditions can not be directly measured, analysis of future years should incorporate the following default values for the PHF unless better information is available:

- 0.85 for minor street inflows and outflows
- 0.90 for minor arterials
- 0.95 for major streets

Engineering judgment must be used in the selection of PHFs for future years. In cases where the existing PHF is higher than the default value for the future PHF, it may be appropriate to retain the existing value for the future year, as PHFs do not typically decrease as traffic volumes and congestion increase. Likewise for areas that have low existing peak hour factors, using the future PHF default values could produce results that would underestimate the future traffic conditions. For areas with aggressive traffic demand management strategies contained in an adopted plan, a different PHF (to reflect spreading of the demand) may be used for future year analysis if agreed to by ODOT during the scoping process. For areas with pronounced peaking characteristics, such as industrial sites and schools, PHFs lower than the default values listed above should be used.

5.3.4 Special Cases

Signal Warrants

For purposes of determining traffic signal installation recommendations, the peak 15-minute period is not a typical consideration, as signal warrants are typically based on longer time frames such as 8-hour, 4-hour, or 1-hour durations (minimum).

SIGCAP2

SIGCAP2 does not directly apply a PHF. This program is most useful for preliminary signalized intersection analysis, such as to determine whether more detailed analysis is warranted using other software that incorporates a PHF.

Other Time Periods

Some situations may call for time periods other than the 15-minute peak to be evaluated (including shorter time periods, such as preemption time during train crossings).

5.4 Access Management

Access management includes the spacing, design, operation and control of all public and private approaches (driveways, streets, ramps, etc.) to a roadway in a manner that balances the competing needs of property access with safe and efficient travel on the transportation system in accordance with pre-established management objectives. These management objectives typically reflect a functional hierarchy where facilities such as freeways and major arterials give priority to through travel, while minor collectors and local streets provide for more direct property access.

5.4.1 Impacts of Access Management Implementation

Because every approach to a roadway creates new conflict and decision points, the reduction and orderly provision of access can have direct benefits to safety and the efficient flow of traffic. Drivers are more likely to have a collision when required to react to multiple conflicts. Numerous studies from around the nation have shown that reducing access density reduces crash rates.[3] Therefore, the implementation of cost-effective access management techniques, such as median construction, left turn prohibitions, and approach consolidation, can extend the life of existing transportation facilities delaying the construction of more expensive improvement projects and preserving the investment in the infrastructure.

Some of the benefits of access management include:

- Reduction in vehicular crash rates.
- Improved travel efficiency with fewer delays.
- Enhanced bicycle and pedestrian environment with fewer vehicle conflicts.
- Improved pedestrian crossings where medians can be used as refuges.
- Improved movement of goods and services.
- Reduction in vehicular emissions.
- Improved fuel efficiency.
- Avoiding impacts to private properties from roadway widening.
- Efficient customer access to adjacent businesses.

5.4.2 ODOT Access Management Policies: 1999 Oregon Highway Plan

ODOT's policies regarding access management are published in Goal 3 of the *1999 Oregon Highway Plan (OHP)*, which includes the establishment of a

[3] *Access Management Manual*, Transportation Research Board, Washington, D.C., 2003, p. 15.

highway classification system and corresponding management objectives and spacing standards, direction for the use of medians, special consideration for interchange areas, and an allowance for deviations and appeals. These policies were used as the basis for the rules and procedures adopted for the governing of highway approaches in OAR 734-051.

5.4.3 OAR 734-051: Highway Approaches, Access Control, Spacing Standards and Medians

The administrative rules contained within OAR 734-051 govern all approaches in existence and approach applications filed after March 1, 2004. While these rules are based on the policies from the *1999 OHP*, they have the force and effect of law and shall overrule the policies should any conflict arise. The rules contain detailed procedures and criteria that shall be followed for all decisions affecting highway access including approach applications, site plan reviews and project development.

5.4.4 Evaluation of Existing Access Conditions

The extent to which existing access conditions are evaluated may depend on the type of project. An evaluation of access conditions as part of a planning study, such as a transportation system plan or refinement plan, may be conducted at a lower level of detail if recommendations for improvements are not intended to be carried out immediately. However, for development review and transportation facility projects, where action will occur within a time frame of less than 5 years, a greater amount of information will be needed.

Long-Range Implementation: Planning Level Evaluation

For projects such as transportation system plans, corridor plans and refinement plans, recommendations regarding access management are somewhat conceptual and generally focus on long-range implementation over a 20-year planning period. Detailed information about individual properties is not necessary since things like property ownership and site circulation may change before any action is taken. For these types of projects existing approach spacing and local street connectivity are the primary elements of interest.

For a given corridor, the number of existing approaches and the distances between them should be recorded and compared to the applicable access management spacing standards for that facility. It may be easier to display this information by presenting it as an access density, where the number of existing access points per mile is compared to the maximum access points per mile that would be allowed under the access management spacing standards. In addition, any physical restrictions such as topography, waterways and historic features that may limit the ability to meet access management spacing standards should be recognized.

The condition of the existing local street system should also be examined, because improved connectivity can divert trips away from the highway and provide alternate means of property access. Identify the number and location of public street approaches to the highway and compare it to what would be allowed by the applicable access management spacing standards. If some public approaches are too close together, look for opportunities to consolidate them or increase the distance between them. Opportunities to construct parallel roadways (e.g., frontage roads) and new public approaches that would have adequate spacing and could provide shared access to multiple properties should also be explored. In addition, existing public approaches maintaining poor alignment or inadequate sight distance should be identified for improvement by future projects.

Short-Range Implementation: Land Development and Transportation Projects

For projects where some or all recommended actions on individual approaches will be carried out within 5 years or less, a significant amount of information will be needed to assure each property is addressed appropriately. These types of projects typically include land development proposals, transportation facility projects, access management plans (AMPs) and interchange area management plans (IAMPs). The types of information needed can generally be categorized as either physical characteristics or access rights. Work with the District permits personnel to get detailed data.

As with the long-range planning projects, when assessing existing conditions, the existing access spacing should be compared to the applicable access management spacing standards, and potential improvements to the local street system should be considered. In addition, opportunities to make immediate improvements to property access must be explored, such as the elimination of approaches, relocation of approaches to non-state facilities and the establishment of shared approaches between multiple properties.

For more detailed recommendations and requirements regarding the treatment of access proposals, ODOT's *Access Management Manual* and PD-03, an Operational Notice titled "*Project Development Access Management Sub-Teams,*" which has been included in the *Access Management Manual*, should be consulted. Adopted AMPs and IAMPs should also be consulted, if they exist.

5.5 Sight Distance

The length of roadway ahead that is visible to a driver is often referred to as "sight distance." The amount of visible roadway needed by a driver at any given time depends on the maneuvers or decisions that must be made at that moment. The four basic categories of sight distance are:

1. Intersection Sight Distance (Desirable)
2. Stopping Sight Distance (Minimum)
3. Decision Sight Distance
4. Passing Sight Distance

While each of these is briefly described below, intersection and stopping sight distance are most frequently examined in traffic analysis. For additional information on sight distance refer to ODOT's *Highway Design Manual*.

- ***Intersection sight distance (desirable)*** is considered adequate when drivers at or approaching an intersection have an unobstructed view of the entire intersection and of sufficient lengths of the intersecting highways to permit the drivers to anticipate and avoid potential collisions. Sight distance must be unobstructed along both approaches at an intersection and across the corners to allow the vehicles simultaneously approaching to see each other and react in time to prevent a collision. Intersection sight distance should be obtained at every road approach, whether it be a signalized intersection or private driveway. In no case should the sight distance be lower than safe stopping sight distance (minimum).
- ***Stopping sight distance (minimum)*** is the minimum distance required for a vehicle traveling at a particular design speed to come to a complete stop after an obstacle on the road becomes visible. Stopping sight distance is normally sufficient to allow an alert and prudent driver to come to a hurried stop under normal circumstances.
- ***Decision sight distance*** should be provided at locations where multiple information processing, decision making and corrective actions are needed. Sample locations where decision sight distance is needed include unusual intersection or interchange configuration and lane drops.
- ***Passing sight distance*** is the minimum distance required for a vehicle to safely and comfortably pass another vehicle. If adequate passing sight distance opportunities cannot be accommodated in the project design, passing lanes or climbing lanes should be considered. See Chapter 6.

5.6 Multi-Modal Analysis

This section left intentionally blank while under development.

5.7 Other Analysis Issues/Procedures

While working on various types of projects, a number of situations may arise requiring analysis methodologies not discussed in this manual. Under these circumstances the ODOT Region Traffic staff or the Transportation Planning Analysis Unit should be contacted for a recommendation. Note: Region Traffic and TEOS are responsible for work zone and pavement design analysis. If ODOT does not have a preferred analysis methodology to offer, there are a number of technical resources available for consultation. Non-standard analysis submissions shall include thorough documentation of assumptions, methods and calculations and engineer's stamp. A listing of several common resources for transportation analysis techniques is included in Appendix A.